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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE BY BOTTOM ASH IN CEMENT CONCRETE

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ABSTRACT- *Bottom ash is a by-product of burning of pulverized coal. It is also one of the major solid wastes coming from Power Plant industries. Currently about 1528 Mt of bottom ash is generated in India every year. The disposal of large quantity of bottom ash dumped in to open spaces, poses increasing problems of storage occupying a lot of space The aim of the present work is to study the possibilities of replacing the part of fine aggregate by Bottom ash. Because of storing issues, the waste negatively affects the environment. To solve this problem, an attempt was made to check the effectiveness of bottom ash as a partial replacement of fine aggregate. Fine aggregate was replaced up to 50% bottom ash by the weight of fine aggregate and evaluating its compressive strength, split tensile strength and flexural strength. The optimum gained after 7 and 28 days curing period was found to be 10% bottom ash + 90% fine aggregate.*

Keywords: Bottom ash, concrete, compressive strength, split tensile strength, flexural strength

1. INTRODUCTION

Concrete is a material synonymous with strength and longevity. It has emerged as the dominant construction material for the infrastructure needs of the twenty-first century. In addition to being durable, concrete is easily prepared and fabricated from readily available constituents and is therefore widely used in all types of structural systems.

In general the fine aggregates used in the production of concrete was natural river sand. Now a days these natural sources like river sand are exhausting gradually around the world so, their protection of environment and saving of natural resources the construction industry is look for the alternative constituent material for making concrete so, there is need for replacement of sand in India. The challenge for the civil engineering community in the near future is to realize projects in harmony with the concept of sustainable development and this involves the use of high performance materials and products manufactured at reasonable cost with the lowest possible environmental impact energy is the main backbone of modern civilization of the world over, and the electric power from thermal power stations is a major source of energy, in the form of electricity. In India, over 70% of electricity generated in India, is by combustion of fossil fuels, out of which nearly 61% produced by coal-fired plants. This results in the production of roughly 100 ton of ash. Most of the Bottom the ash has to be disposed of either dry, or wet to an open area.

1.1 Role of Fine aggregate in concrete

The fine aggregate plays a very important role for imparting better properties of concrete in its fresh and hardened state. Aggregate in concrete is structural filler. Aggregate occupies most of the volume of the concrete. It is the stuff that the cement paste coats and binds together. The composition, shape, and size of the aggregate all have significant impact on the workability, durability, strength, weight, and shrinkage of the concrete. Aggregate can also influence the appearance of the cast surface, which is an important consideration in mixes.

1.2 Bottom ash

Bottom ash is a by-product of burning coal at thermal power plants. Bottom ash particles are much closer than the fly ash. It is a coarse, angular material of porous surface texture predominantly sand sized. This material is composed of silica, alumina, and sulfate grain sizes typically range from fine sand to gravel in size. Chemical composition of bottom ash is similar to fly ash but typically contain greater quantity of carbon. It consists of combustible materials, and is the residual part from the incineration of household and similar waste. Sand stone raw bottom ash is a granular material that consists of a mix of inert materials such as sand, stone, glass, porcelain metals and ash from burnt materials.

Fig -1: Bottom ash

2. OBJECTIVES OF WORK

The following are the objectives.

1. To determine the optimum content of bottom ash as a substitute for fine aggregate (sand) in concrete.
2. To study the fresh properties of the concrete containing Bottom Ash.

3. MATERIALS USED

A. Cement

In this experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 - 1989was used. The physical properties of the cement were determined as per IS: 4031-1968 and are presented in table I.

Table I: Properties of Cement (OPC 43)

Sr.No	Material Property	Results Obtained
1	Specific gravity	3.24
2	Finess modulus	4%
3	Standard consistency	33%
4	Initial setting time	32Min
5	Final setting time	567 Min
6	Compressive strength 7-Days(Mpa) 28-Days(Mpa)	24 43.20

B. Sand (Fine Aggregate)

Locally available river sand belonging to zone II and passing through 4.75mm sieve of IS 383-1970 was used for the project work. The physical properties of the fine aggregates are presented in below table II.

Table II: Properties of Fine Aggregate (Sand)

Sl.No	Material property	Test Results obtained
1	Specific gravity	2.70
2	Fineness modulus (%)	2.90
3	Bulk density (kg/m3)	1600
4	Water absorption (%)	1.70

C. Corse Aggregate

Locally available Quarried and crushed granites stone aggregate conforming to IS 383-1970 are used in this work. The physical properties of coarse aggregate given in the below table III.

Table: III Physical properties of coarse aggregate

Sl. No	Material property	Test Results obtained
1	Specific gravity	2.72
2	Fineness modulus (%)	7.60
3	Bulk density (kg/m^3)	1660
4	Water absorption (%)	0.65

D. Bottom Ash

Bottom ash is a by-product of combustion of pulverized coal. This coal bottom ash is physically coarse, porous, glassy, granular, greyish and incombustible materials that are collected from the bottom of furnaces that burn coal. The physical properties of coarse bottom ash given in the below table IV.

Table IV Physical properties of Bottom ash

Sl. No	Material property	Test Results Obtained
1	Specific gravity	1.98
2	Fineness modulus (%)	2.55
3	Bulk density (kg/m^3)	1448
4	Water absorption (%)	1.52

4. METHODOLOGY DETAILS

1. Collection of Raw Materials
2. Basic Tests on Collected Materials as per IS Codal provisions.
3. Preparation of Mix Design:
   The M30 grade mix design was prepared by using as per IS 10262:2009 codal provisions. The concrete mixes are prepared varying the bottom ash content as 0%, 10%, 20%, 30%, 40% and 50% by weight with replacement of fine aggregate. The prepared mixes are studied for both fresh as well as hardened properties.
4. Casting of Specimens.
5. Curing of Specimens for 7 & 28 days.
6. Testing of Concrete Specimens
   - Tests on Fresh Concrete
   - Tests on Hardened Concrete

5. TEST RESULTS

5.1. Workability test results

Table V: workability test results

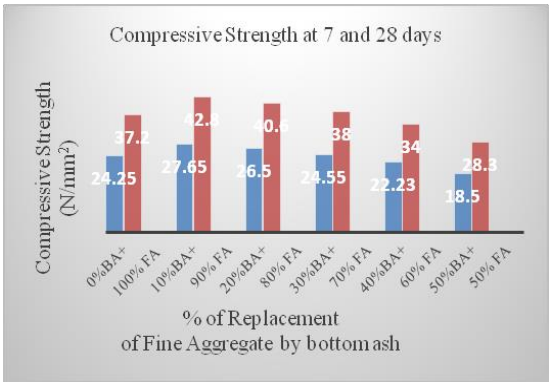
Percentage replacement of Fine Aggregate by Bottom Ash	Fresh properties tested		
	Slump (mm)	Compaction Factor	Vee-Bee Degree (Sec)
0%BA+100% FA	88	0.90	6
10% BA+90% FA	85	0.89	8
20% BA+80% FA	84	0.87	12
30% BA+70% FA	83	0.86	20
40% BA+80% FA	82	0.84	22
50% BA+50% FA	81	0.83	30

5.2. Compressive Strength test

Compressive strength of the concrete design mix was check by casting and testing of cubes (size 150 mm x 150 mm x150 mm) after the curing period of 7 days &28days. The obtained results are tabulated below.

Table VI: Compressive strength results

%replacement of fine aggregate by Bottom ash	7-Days Mpa	28-Days Mpa
Nominal mix	24.5	37.20
10% BA	27.65	42.80
20% BA	26.50	40.60
30% BA	24.55	38.00
40% BA	22.33	34.00
50% BA	18.50	28.30



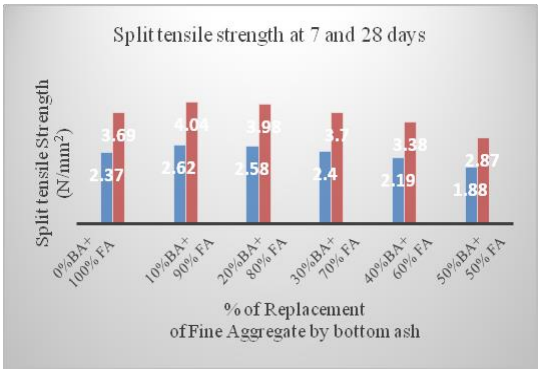
Graph No. 1: Compressive Strength of Cubes of curing period 7 and 28 days

5.3. Split tensile Strength test

Split tensile strength of the concrete design mix was check by casting and testing of cylinders (size 150 mm dia & 300 mm length) after the curing period of 7 days &28days. The obtained results are tabulated below.

Table VII: Split tensile strength results

%replacement of fine aggregate by Bottom ash	7-Days Mpa	28-Days Mpa
Nominal mix	2.37	3.69
10% BA	2.62	4.04
20% BA	2.58	3.98
30% BA	2.40	3.70
40% BA	2.19	3.38
50% BA	1.88	2.87



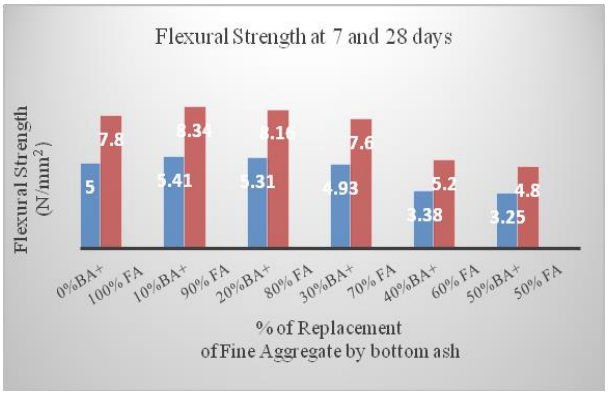
Graph No. 2: Split tensile Strength of Cylinders of curing period 7 and 28 days

5.3. Flexural Strength test

Flexural strength of the concrete design mix was check by casting and testing of beams (size 100 mm x 100 mm x 500 mm) after the curing period of 7 days & 28days. The obtained results are tabulated below.

Table VIII: Flexural strength results

%replacement of fine aggregate by Bottom ash	7-Days Mpa	28-Days Mpa
Nominal mix	5.00	7.80
10% BA	5.41	8.30
20% BA	5.31	8.16
30% BA	4.93	7.60
40% BA	3.38	5.20
50% BA	3.25	4.80



Graph No. 2: Flexural Strength of beams of curing period 7 and 28 days

6. CONCLUSIONS

- The workability of fresh concrete with slump cone test is gradually increasing with increase of bottom ash content in concrete and the maximum slump is obtained for 0% Bottom ash+ 100% Fine aggregate

and compaction factor is gradually decreasing with increase of bottom ash content in concrete and the maximum compaction is obtained for 0% BA + 100 % F.A.

- The specimens with bottom ash as replacement with fine aggregate was found to be better in compression which has compressive strength of 14.02% and 15.05% more than that of nominal mix concrete after 7 days and 28 days curing period respectively for 10% Bottom ash + 90% Fine aggregate.

- Better split tensile strength was achieved with the replacement to fine aggregate with Bottom ash in concrete. The split tensile strength was increased up to 9.4% and 10.5% when compared to that of the nominal mix concrete after 7 days and 28 days curing period respectively for 10% Bottom ash + 90% Fine aggregate.

- Good flexural strength was achieved with the replacement to fine aggregate with bottom ash in concrete. The flexural strength was increased up to 6.92% and 8.2% when compared to that of the nominal mix concrete after 7 days and 28 days curing period respectively for 10% Bottom ash + 90% Fine aggregate.

Considering the all above points it is concluded that the optimum utilization of Bottom ash is 10% in concrete as replacement to the fine aggregate to obtain a considerable design mix.

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